CLIMATE ACTION TRAINING FOR THE FASHION INDUSTRY

Module 5.2: Renewable Energy and Biomass

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by

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FABRIC Asia

Global Climate Action
United Nations Climate Change

Contents

1. Lesson: Introduction

Welcome to the last module of the online training 'Climate Action for the Fashion Industry'!

1.1 Learning objectives

Previously, you learnt about energy saving measures to both reduce energy consumption and meet emission reduction targets. In this module, you will learn about renewable energy (RE) solutions that can reduce your Scope 1 and 2 emissions.

More specifically in this module, you will learn about:

- **Why implement RE solutions** – What are the benefits for companies who source RE? What is the emission reduction potential in your country?
- What are some **typical RE solutions** textile and garment factories have used to achieve RE ambitions – especially to reduce Scope 2 emissions?
- **Renewable Electricity:** What is the difference between on-site and off-site renewable electricity?
    - **On-site Renewable Electricity** – how does an on-site solar PV system work? What is the CAPEX and OPEX model? What is there to consider when installing a solar PV on site?
    - **Off-site Renewable Electricity** – is an off-site power purchase agreement (PPA) possible? How can we prepare for off-site solar power sourcing?
- **Renewable Heat: Biomass for heating (and electricity generation)** – how does biomass work? What are the main applications of biomass in the textile and garment industry? What are the different methods and technologies? What are the cost saving potentials?

1.2 Structure of module

All these questions will be covered in the three following lessons:

- Lesson 2: Renewable Energy Solutions
- Lesson 3: Renewable Electricity
- Lesson 4: Biomass

After these lessons, you can review and apply what you have learned at the end of the module by:

- checking your knowledge in a short **quiz** covering the main topics of this module; and
- doing a pre-feasibility assessment for your factory in a **real-life assignment**

You can also have a look at the **frequently asked questions (FAQs) and additional resources** for this module.

How much time is needed for this module?

Going through the core content of this module will take approximately 2 – 2.5 hours. For the assignment, set aside another two (2) hours.

Before we start, take a minute to reflect:
What knowledge do you expect to gain from taking this module?

Think about this before you continue. If you like, write down your expectations so that you can revisit them at the end of the module.

2. Lesson: Renewable energy solutions

Before we start, what do we actually mean when we talk about renewable energy (RE)?

Renewable Energy is energy that is derived from natural sources that are not depleted when consumed i.e. they are replenished at a higher rate than they are consumed (Source: UN). For instance, solar and wind energy are renewable energy sources, in contrast to fossil fuels like coal, oil or gas they cannot be depleted when used. Further, using RE also does **not** produce harmful greenhouse gases as in the case of fossil fuels (the only exception among RE here is bioenergy which produces emissions when use, however these are not counted if the bioenergy comes from replenishing sources).

Companies – big and small – across the world are increasingly looking into renewable energy (RE) to power their operation.

What do you think are the main reasons for companies to source renewable energy?
Please gather your own ideas first.

2.1 Recap from previous modules

Renewable energy offers various benefits to the textile and garment industry. To start, renewables are an effective and credible way to reduce your greenhouse gas emissions.

Let's recall what we learnt in **Module 3.**

Scope 1: Direct emissions

Scope 1 emissions are the **most direct emissions**, as companies have control over the emissions sources and the type of energy used which generates these emissions. They include emissions from all energy produced on-site, such as fuel combustion, company vehicles, and fugitive emissions.

If a company is in the business of fashion, Scope 1 includes emissions from fuel for operated warehouses, boilers/other heat applications, or emissions from company-owned vehicles.

Scope 2: Emissions from purchased or acquired electricity, steam, heat, and cooling

Scope 2 emissions are one step beyond a company's immediate control. They come from the **purchase of electricity or heat (can include also purchased steam)** made by a company to keep its facilities running. Therefore, the emissions would depend on the type of fuel or resources used by the utilities to generate the electricity and heat delivered to your factory.

Almost all businesses generate Scope 2 emissions due to the purchase of energy in form of electricity or heat.

Scope 3: Indirect emissions

Scope 3 includes both upstream activities – emissions related to products purchased by a company – and downstream activities – those related to the products they sell.

Although this module will not focus on Scope 3 emissions, in theory you can reduce your Scope 3 emissions if your suppliers invest in RE, just as a textile factory's Scope 2 emissions are Scope 3 reductions for your clients.

Depending on which tier your company is, purchased electricity will be a large source of emissions for your factory. Check out the Scope 2 emission reduction potential with renewables in your country!

This map shows the **grid emission factor** of power grids in different countries. A grid emission factor is a measure of CO_2 emission intensity per unit of electricity generation in the grid system (tCO_2/MWh).

The higher the grid emission factor (emission unit/MWh) of electricity from your national grid, the higher the potential impact is when switching to renewable sources.

Bangladesh 0.671 kg CO_2e/kWh	**Cambodia** 0.235 kg CO_2e/kWh	**Vietnam** 0.833 kg CO_2e/kWh
Myanmar 0.353 kg CO_2e/kWh	**Pakistan** 0.393 kg CO_2e/kWh	**India** 0.976 kg CO_2e/kWh
Turkey 0.466 kg CO_2e/kWh	**Bulgaria** 0.440 kg CO_2e/kWh	**Romania** 0.312 kg CO_2e/kWh
Italy 0.468 kg CO_2e/kWh	**Poland** 0.815 kg CO_2e/kWh	**Spain** 0.345 kg CO_2e/kWh
	Portugal 0.258 kg CO_2e/kWh	

To calculate the Scope 2 emission-reduction potential of renewable electricity (RE), simply follow this formula:

$$Emission\ reduction\ potential =$$

$$Consumption\ of\ grid\ electricity\ to\ be\ replaced\ by\ RE\ [MWh]\ x\ Grid\ emission\ factor\ [t\frac{CO2e}{MWh}]$$

2.2 Benefits of renewable energy

However, emission reduction is not only the benefit of renewables!

It makes business sense

Electricity and fuel prices can be volatile and high. Renewable energy can help manage, and even decrease, your energy costs.

- In many countries, RE electricity generation costs are typically on a par with, or **significantly lower than, electricity produced from fossil fuels**. RE electricity is also not subject to the high price fluctuation witnessed with fossil fuels.
- Over the last decade, renewable power generation costs have been falling, driven by steadily improving technologies, economies of scale, competitive supply chains and improving developer experience. **Costs for electricity from utility-scale solar photovoltaics (PV) fell 85% between 2010 and 2020** only with a slight stagnation in the recent years due to the pandemic **(Source: IRENA).**
- Biomass fuels can be in some countries on competitive levels with gas fuels, coal and heating oil.
- RE can increase your chances of **compliance with the potential regulatory changes, as well as client requirements**, for increased sustainability.
- RE increase the security of electricity supply at your factories given the expected

Competitiveness

- RE **creates a differentiator** from other suppliers for fashion brands.
- RE meets a growing consumer demand for low-carbon products and revenue can be potentially enhanced as products which are certified to be manufactured using RE are increasingly becoming more attractive to consumers in the fashion industry.
- Fashion brands are looking for low-carbon suppliers to help them **achieve the sustainability targets.**

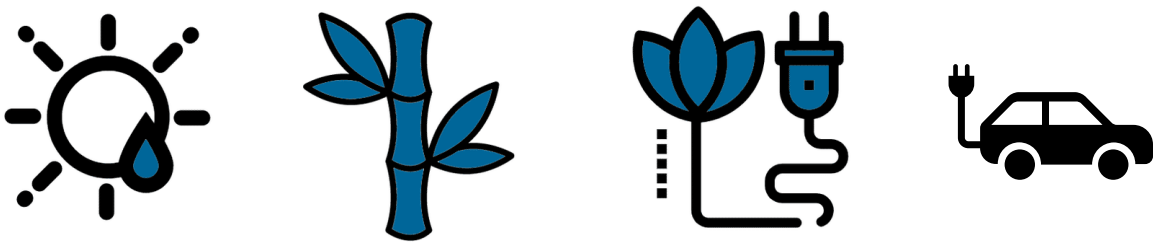
Sustainable pathway

- More fashion brands are setting ambitious **sustainability targets and joining global initiatives,** such as the RE 100, the SBTi and the Higg Index.
- There is an **increasing pressure in the fashion market** to match RE commitments **throughout the complete value chain**. Therefore, fashion brands are looking for suppliers who are able to deliver products and services which are produced/manufactured using low carbon resources.
- As suppliers, your actions to reduce Scope 1 and 2 emissions through RE solutions would make a significant contribution towards **helping your customers meet their targets**, due to the high emission intensity in your geographical region.

Now that we know that renewables are an **important asset** to your business and before we explore solar PV and biomass in more detail, let's briefly explore what other emission reduction solutions are available out there for each of the emission scopes.

2.3 Scope 1 emission reduction solutions

To address their direct emissions from fuel combustion on-site the following renewable energy solutions exist:



Please note that this is not an exhaustive list of Scope 1 emission reduction solutions.

Image 1: Solar thermal heating

The use of solar radiation as heat energy is known as solar thermal heating. A solar thermal system works by harnessing the sun's energy and converting it into heat that can be used in conjunction with boilers, for example.

Image 2: On-site biomass boiler

Heat produced by the combustion of biomass in place of fossil fuels helps to reduce carbon dioxide released into the atmosphere. The emitted CO_2 from biomass combustion has previously been absorbed during the lifetime of the biomass (e.g. biomass residues, agricultural residues, organic debris). Therefore, **biomass has the potential to be carbon neutral**, however other GHG emissions (not carbon) need to be accounted for and feedstock needs to be sourced sustainably.

Image 3: On-site combined heat and power (CHP) biomass plant

CHP is an energy-efficient technology that generates electricity and captures the heat that would otherwise be wasted to provide useful thermal energy, such as steam or hot water. By using biomass as fuel, the **generated electricity and heat from CHP systems would be considered renewable** – so in fact you can reduce Scope 1 and Scope 2 emissions with CHP!

Image 4: Electrification

Electrification of thermal processes could also be a possibility to reduce fossil fuel consumption with the advantage that electricity can be "greened" easier, as will be explained in the following section. However, to effectively reduce emissions, the electricity used in, for instance, electric boilers must come from renewable sources.

Later in this module, we will review **biomass opportunities** in more detail as it is the most mature and applicable reduction solution for the textile and garment industry.

2.4 Scope 2 emission reduction solutions

To reduce Scope 2 emissions from purchased electricity, four key solutions exist:

1. **On-site generation (such as rooftop solar)**

Electricity is produced via solar PV panels on rooftops or nearby land for direct consumption, storage or export. With an on-site system, you can either **directly consume, store (in the case of storage solutions, such as batteries) the generated electricity to power your operations or feed the excess electricity into the grid**. With on-site generation you can either invest in the system yourself (CAPEX model), or have the system financed by a third-party (OPEX model). We will explore this solution in greater detail later on.

Important to remember: On-site power generation is not limited to solar PV, and generally refers to renewable electric power produced at the site of your business rather than imported from distribution grids. This means that, for example, you can reduce Scope 2 emissions with biomass power generation.

This solution is **generally available** in almost all countries.

2. Corporate (off-site) PPA

A corporate PPA is a long-term agreement between a corporate buyer of electricity (factory, for example) and a RE project, such as a wind or solar farm. The RE project is typically not located on or near the factory's premises as the generated electricity is transferred to the factory through the local power utility lines. In some PPA cases the local grid connection is not even needed as the concept is completely financially structured.

The PPA is signed between a company and RE project to buy the RE power and the associated EACs (e.g. I-RECs) at an agreed price. Wind and solar PV are the most common technologies for off-site corporate PPAs.

Off-site corporate PPAs are widely available in the United States, Europe and Australia. In Asia, off-site PPAs are only available in India, Singapore, Japan and Taiwan with near-term (next 2–3 years) opportunities in Vietnam, the Philippines and Malaysia.

3. Energy attribute certificates (EACs)

An EAC is a tracking tool certifying that one megawatt-hour (MWh) of generated renewable electricity was produced from an eligible renewable source. By purchasing each unit of EAC, the factory would claim the use of the generated electricity by a specific RE power plant (this could be hydro, solar, wind and other RE sources, which is supplied to the grid).

The factory could purchase an equivalent amount of EACs to the amount of electricity consumption it wants to certify as renewable from a credible EAC supplier. This could range anywhere from 0 up to 100% of the factory's total electricity consumption.

With EACs there is no physical delivery of RE to the facility/factory, as it is just a tracking tool. The factory would continue to source energy from local utilities to power its operations.

4. Green tariffs

A green tariff refers to a retail electricity supply contract with the local utility, where each unit of the grid electricity consumed by the customer would be matched with an equivalent amount of EACs purchased and retired by the utility on behalf of the customer. This specific tariff comes usually with a price premium compared to the conventional retail price.

This solution is **not available** in most countries in the APAC region. Therefore, there will be no focus on this solution.

2.5 Claiming emission savings from RE

When conducting one of the previously mentioned scope 2 emissions reduction solutions, it is important for companies to ensure that the consumption of renewable electricity is correctly claimed to be able to account for the achieved emission savings.

For a correct claim, international organizations (GHG Protocol, SBTi) accept emission reductions if a company can back each MWh of consumed electricity, that it claims to be renewable, with a respective Energy Attribute Certificate. As we learned before, this certificate is a tracking tool that

ensures that the electricity is generated from an eligible renewable source to improve the credibility and consistency of a claim.

This principle applies for on-site generation (if electricity is fed into the grid), off-site PPA, unbundled EACs (i.e. EAC sold without physical transfer of electricity) as well as green tariff.

Renewable energy solutions for textile factories

Some key material providing information about drivers for corporate renewable energy procurement:

Growing renewable power: companies seizing leadership opportunities, published by RE100 in December 2020.

Business Leadership in the Transition to Renewable Electricity published by RE100 in September 2020.

On-site renewable electricity and storage for corporates: business models & policy framework, published by RE-Source in December 2020

Renewable Energy Market Update - Outlook for 2022 and 2023, published by the International Energy Agency in May 2022

Renewable Power Generation Costs in 2021 published by the International Energy Agency in July 2022

3. Lesson: Renewable Electricity

As electricity is one of the biggest emission sources and an important cost factor in the textile supply chain, especially for Tier 1 suppliers, this lesson will focus on the possibilities to source electricity from renewable sources. Renewable electricity can be produced through different **technologies with solar photovoltaic (PV) and wind power being the most relevant ones**. As learnt in the previous lesson, companies that want to reduce their scope 2 emissions coming from the purchase of grid electricity, can source renewable electricity either through:

- installing solar PV on their site,
- purchasing electricity from a renewable electricity project, that is located off-site or,
- if otherwise not possible, through the purchase of Energy Attributes Certificates

In the following you will deep dive into each of the three sourcing options.

3.1 On-site Renewable Electricity

The installation of solar PV plants on-site is the most relevant way for textile and garment factories in South and Southeast Asia to procure renewable electricity. **On-site solar means that the system is installed in the factory area.**

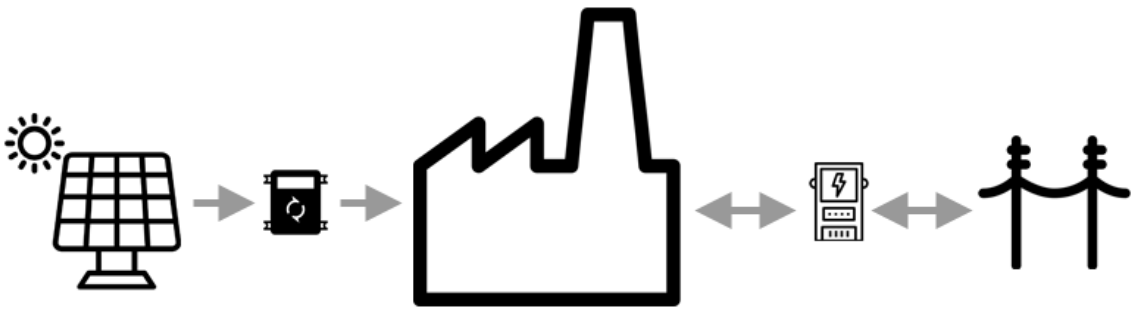
Typically, factories will install the solar system on available and suitable **rooftop** space, but you can also install the system if you have available space **near the factory** (ground-mounted).

Photo: Solar panels on the rooftop of a production facility**.**
Source: American Eagle

Photo: Ground-mounted solar system.
Source: Pixabay free for commercial use

3.1.1 Basics

Before we dive deeper into the key aspects of on-site solar PV, let's have a look at the basic technical concept of it. The following chart shows from left to right how renewable electricity from on-site solar PV works.



Explanation from left to right:

Solar panel Sunlight hits the solar PV panels, creating direct current (DC) electricity.
Inverter: Inverters turn the DC electricity generated by the solar PV panels into alternating current (AC) electricity which is the standard form of electricity used to power electronic equipment.
Factory: AC electricity is used to power the factory.

Meter: A bi-directional meter measures the grid power used and, in case net metering is implemented, the excess power is exported to the grid.
Grid: The grid continues to power your factory when the on-site solar PV system does not generate enough power for your factory. In case net metering is allowed and is implemented in your factory, the grid can also receive the excess generated power from your factory when the on-site solar PV system generates more power than needed by your operations.

Moving forward let's have a look at the fictional case study below.

Chino Cotton Textile wants to invest in the future.

Chino Cotton's management is exploring options to reduce factory emissions and also save money on power costs. To meet these objectives, they plan to install an on-site solar PV system.

3.1.2 Key considerations

After having a good understanding of the basic concept of on-site solar PV, Chino Cotton Textile now wants to move forward. To do so, there are now some key considerations, that need to be kept in mind:

1) Does my factory have a suitable space for a solar PV system?	**a)** The rooftop should be structurally sound. If a roof is old or in need of repairs or replacement, a PV system should not be installed until the repairs are completed. Considerations need to be given to the 'Operation & Maintenance' of the Solar Panels post installation especially if the rooftop is prone to regular dust. The rooftop should have the space, accessibility, and strength to accommodate staff for cleaning the panels and (ideally) have access to water for this purpose. **b)** Expected roof lifetime should be, at least, as long as the expected payback period of the system or preferably even up to 25 years (equal to the lifetime of the PV system). **c)** A significant portion of the rooftop space should be free from shading caused by walls, vents, skylights, air-conditioner equipment, walkways, etc. (especially between 10.00 am and 3.00 pm, the peak solar hours). To learn more about assessing the technical suitability of a solar project, please refer to GIZ's Fabric Asia Knowledge Product Series (available under 'Further Resources tab in atingi) or discuss with a trusted adviser.

2) What is the expected system size and output?	Typically, an on-site solar system only covers a small portion of the site's total consumption. The size and output of your solar system depends on various factors, both nature- and technology-dependent, including but not limited to: • Location (solar irradiation) • Space availability 5 – 7 sqm/kWp installed is typically needed • Local season and weather • Local regulations, which is especially relevant in cases where incentives or grid limitations may require system size to be sub-optimal for the available area • The material and efficiency of the solar panels used • Tilt of the roof and the installed modules • The balance of system (BOS) arrangement • Grid interconnection requirements (e.g., system capacity not overloading the transformer/distribution line to which it connects) Contact the local solar solution provider to evaluate what would be the best arrangement and the expected output of the solar PV system applicable to your factory.
3) What are the total expected costs of the system over its lifetime?	The total cost of your system would include the costs of the system throughout its lifespan: a) The procurement of all fixed components (PV panels, inverter, mounting structure, cables, earthing, among others) and installation costs – to purchase and install the solar PV system in your factory b) The operation and maintenance (O&M) costs, including component replacements -– to service and take care of the system throughout its lifespan, ensuring the system is working optimally. As a practical example, the inverters would need to be replaced during the solar PV system use, as it typically would only have around a 10-year life span, while the solar PV panels could be used for up to 20–25 years. c) Miscellaneous: costs for arranging the system procurement tender and permits
4) What are the means to finance the system?	When you invest in a new on-site solar system, you can either self-finance your investment up front (CAPEX) or make instalment periodic payments to a third party over multiple years (OPEX). We will learn more about investment models for this later in this module.
5) What incentives are available?	Depending on where your factory is located, there may be incentives available to increase the business case for solar PV. Example incentives include: **1) a net metering/feed-in tariff scheme that allows you to sell excess generated solar electricity to the grid**, **2) tax reductions and** **3) other subsidies such as concessional financing for RE.** It is important to understand what is available in your market to maximise opportunities. To find out more about benefits and risks of on-site installations, please refer to **GIZ's Fabric Asia Knowledge Product Series (aavailable under Further Resources tab in atingi)**
6) What steps are required to implement solar PV?	Solar PV project development typically consists of fivesteps: • Feasibility and planning

	• Tender process • Construction • Operation • End-of-life management We will explore these steps in more detail later in the module.

3.1.3 Business and procurement models

Among the previously mentioned considerations, a common concern when exploring solar PV is around the cost and financing of the system.

You will likely find yourself asking: **What is the best solar PV investment model for our business?**

As we previously discussed, when you invest in a new on-site solar system, you can either **self-finance your investment up front (CAPEX)** or make **incremental payments to a third party over multiple years (OPEX).**

Although models are different in structure, both can provide cost-saving opportunities.

Let's explore these two models in more detail.

The first option – doing it on your own costs – is called the **'CAPEX model' or 'self-financed model'.**

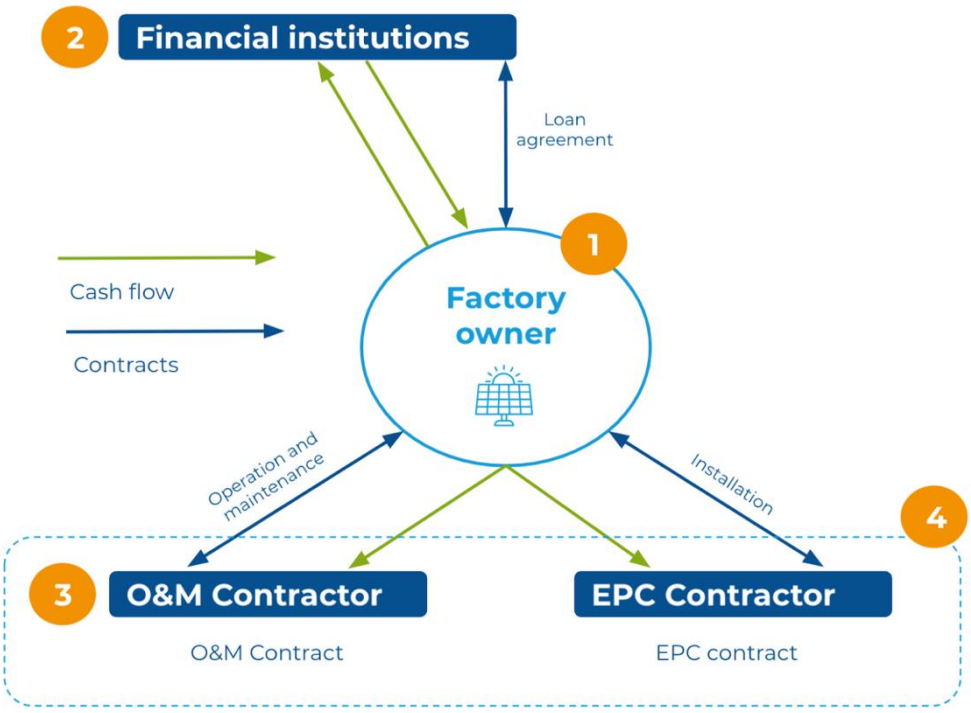


Image: CAPEX Model
Source: South Pole

How the CAPEX model works:

1) The factory owner owns the solar PV system
2) The factory owner can apply for financing via a loan from a bank
3) The installation of the solar system will be completed by a trusted EPC contractor selected through a tender process
4) The factory owner is responsible for operation and maintenance (O&M), however, engage an O&M contractor for a fee (typically annual) to ensure quality

In a nutshell, in the CAPEX model, the entire investment for the rooftop solar system comes from the power user (factory owner). The power user generally hires a solar engineering, procurement, and construction (EPC) company who provides turnkey installation of the entire solar power system and hands over assets to the user.

The factory management (the system owner) is responsible for O&M. However, typically a contractor can provide O&M service as part of the contract for a certain number of years after the system is commissioned. Therefore, the facility owner can rely on the EPC contractor during this period for the agreed O&M activities. You can also manage the O&M in house however, if you engage your personnel to oversee O&M activities, then proper capacity building (i.e. training) must be conducted.

If you cannot pay for the up-front costs of the solar PV system and are not interested in getting a loan from a bank, don't worry – you can still enjoy the benefits of solar PV through the **OPEX model, or third-party financed model**.

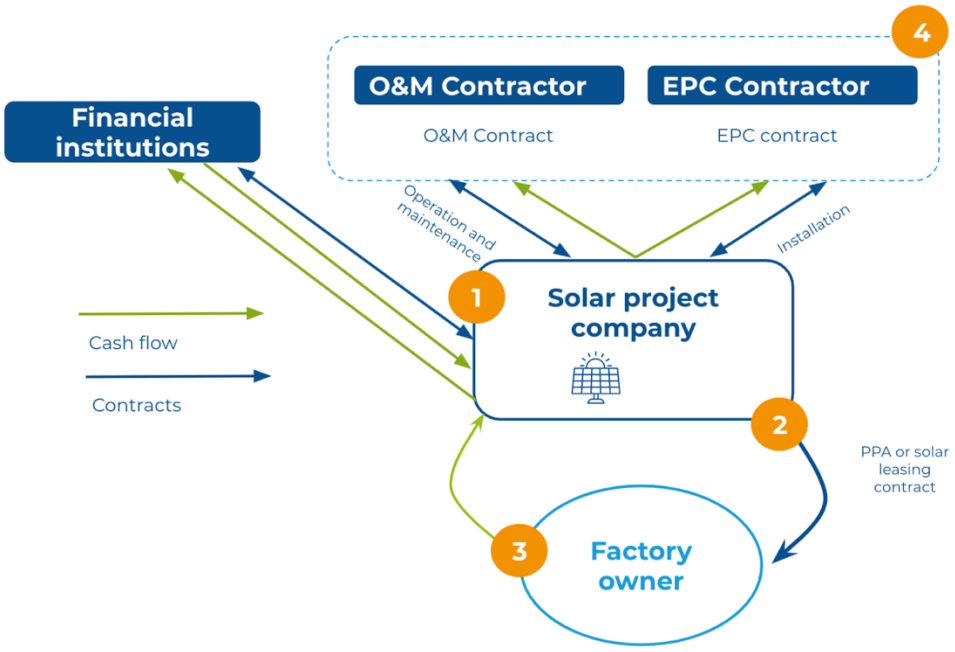


Image: OPEX Model
Source: South Pole

How the OPEX investment model works:

1) A renewable energy service company (RESCO) or other third-party invests in and builds the on-site solar plant.
2) The factory signs a long-term contract, for example a Power Purchase Agreement (PPA) or solar-lease agreement.
3) The factory pays for the power generated under a long-term agreement. Typically, the factory will have a discount per unit price tariff in comparison with grid price.
4) The solar company (contracted third-party) is responsible for O&M throughout the tenure of the contract.

This option is good for factory owners who do not have the up-front capital available to install an on-site solar plant, or do not have access to long-term, low-cost capital.

Did you know?

Short daylight hours do not necessarily mean that an OPEX investment model is a better option. Deciding whether a system is financed through CAPEX or OPEX is mainly up to your financing capability.

If there are short daylight hours in your region this only means that the system may produce less energy than in a place with more daylight hours, potentially decreasing the savings.

However, your consumption profile may match well with it and lead to more savings!

Suggestion: Be sure to engage with a certified advisor/developer to know more about the advantages of a PV system and the potential.

Depending on where your factory is located, there are different types of OPEX arrangements:

- **On-site power purchase agreement (PPA) with self consumption**

  The on-site power purchase agreement (on-site PPA) is usually signed when the factory purchases – partly or fully – the electricity generated, installed, and owned by a third party on the factory's rooftop space. Under a PPA arrangement, you typically pay per kWh for the generated electricity.

- **Solar lease model**

  Under this type of contract, a third-party (typically a RESCO) finances and installs a solar system on the roof of the factory. The third-party is the owner of the system and leases it to the factory on an operational basis. During the lease period, the factory owners pay the developer a monthly fee, either a flat rate or based on the electricity generated by the solar system (depending on the contract). Typically, after the lease period, ownership of the system transfers to the factory owner.

- **On-site power purchase agreement (PPA) with grid injection**

  An On-site power purchase agreement (PPA) with grid injection is typically signed when a third-party (typically a RESCO) only leases the rooftop space from the factory to install a solar system but intends to inject and sell all the electricity produced to the power utility. This is very likely in countries with a Feed-in-Tariff and the claim of certificates is highly important.

Making a credible RE claim with solar PV

Depending on the type of financing solution selected and the type of energy consumption you have, you may **report a reduction in your GHG emissions**.

For facilities consuming electricity from the grid and reducing their grid consumption with the energy produced by the PV system, the reduction is in their Scope 2 emissions (market-based approach).

- If the PV system is owned by you, then you have to make sure that EACs are registered and you retain ownership of them (in markets where EACs are available). In case of a self-consumption scenario, metering data would also be accepted, however, if electricity is fed to the grid, certificates need to be generated and cancelled.

- If the PV system is leased, with energy being delivered to you, then **a contract stating the amount of energy being delivered to you is required**, as well as proof that the attributes of the energy cannot be claimed by another entity.

If the rooftop is leased, then most likely you will not be the owner of the attributes, unless the contract with the PV system owner explicitly states that the attributes of the electricity generated are owned by you. In this case, you also have to make sure that the **attributes of the energy cannot be claimed by another entity**.

Case study: The Sun's the Limit – using innovation and successful partnerships, VF Partner factory installs Vietnam solar panels

VF Corporation's partner factory in Vietnam (Quang Viet) installed 2 MWp of solar panels and is planning to add another 3 MWp installation. With this addition, 90% of captured sunlight will be used for energy and will help decrease factory carbon emissions by 75,000 tons over the next 20-year period. The project is developed in partnership with the International Finance Corporation.

Source: 3BL Media (2020)

[Exercise 3]

CAPEX and OPEX - What are the differences? **Drag the cards to the correct stack.**

CAPEX

- **Ownership**: the factory own the systems
- **Payment**: On the factory's balance sheet
- **Cost saving potential**: Very high. If your system is fully paid for (no debt/loan financing), then you consume all the electricity you generate for free.
- **Operations and maintenance**: Factory is responsible for O&M

OPEX

- **Ownership**: Solar vendor/RESCO owns the system
- **Payment**: Off the factory's balance sheet
- **Cost saving potential**: Medium to high, depending on the agreed discount rate against retail rate with the solar service provider
- **Operations and maintenance**: Typically done by RESCO for a fee

For more detailed information on investment models, please refer to GIZ's Fabric Asia Knowledge Product Series (available under 'Further Resources' tab in atingi).

All right! Chino Cotton has made the decision: they are going to make the investment and build a solar PV on their rooftop.

What steps are required to implement it?

Please think for yourself first, before looking at our feedback.

3.1.4 Implementation process

A rooftop PV system (just as any other on-site renewable project) represents a strong investment that will return its investment in the mid-term and bring earnings in the long term.

The on-site PV system process

To ensure that you are installing a rooftop PV system of the highest quality, a four-step tender process should be followed. These steps should be followed per site where an on-site PV system is to be installed.

If you have several factories in different regions and with varying potentials to install on-site systems, your best course of action is to first create **a roadmap** prioritising the sites with the most attractive business opportunities.

Several elements influence the attractiveness of an on-site PV system investment. It is therefore recommended to go through all the steps with the support of a trusted adviser.

Step 1: Feasibility & planning	
Description	Initial feasibility analysis, including technical, legal and financial aspects. • **Technical:** determine potential characteristics for a PV system installation in the intended location by considering technical (e.g. size, structural viability, historical consumption and potential production profile) and geographical (e.g. irradiance, sun hours and potential shading) factors. • **Legal:** assess applicable permits, subsidies, insurances and power contracts including feed in of residual power. • **Financial:** initial evaluation of the economics of different investment models (e.g. on-site PPA vs own investment, considering different financing options). Check on subsidies or other financial incentives.
Milestone 1	A recommended system set up and business model for your future PV system has been selected. Now you are ready to prepare a tender and go to the market.
Step 2: Tender process	
Description	**Tender design** • Develop the documents needed for the tendering process, such as the Request for Quote (RFQ) documentation and internal evaluation criteria. • Identify suitable and reputable suppliers capable of installing a high-quality system. **Tender issuance and management** • Issue RFQ to the market to request formal offers. • Manage suppliers' relationships (e.g. answer queries and ensure the return of complete sets of data). • Pre-qualify counterparties based on initial responses. **Revision of offers** • Assess proposals and evaluate them qualitatively and quantitatively, applying pre-defined internal criteria. • Develop refined business cases for most promising proposals. • Qualify a set of final suppliers to initiate negotiations. **Negotiation and contracting** • Undergo bilateral negotiations and ensure that all legal documentation required is addressed. • Select the final counterparty and sign the contract.
Milestone 2	There has been a fair, competitive and transparent process and the project is allocated to the winning bidder and ready for implementation.
Step 3: Construction	
Description	**Pre-construction** • Ensure all documentation required from the facility owner is in place for the installation of the project. • If the PV system will inject energy to the grid, ensure that all required documentation is delivered to, and a grid connection approval is delivered by the utility prior to construction start.

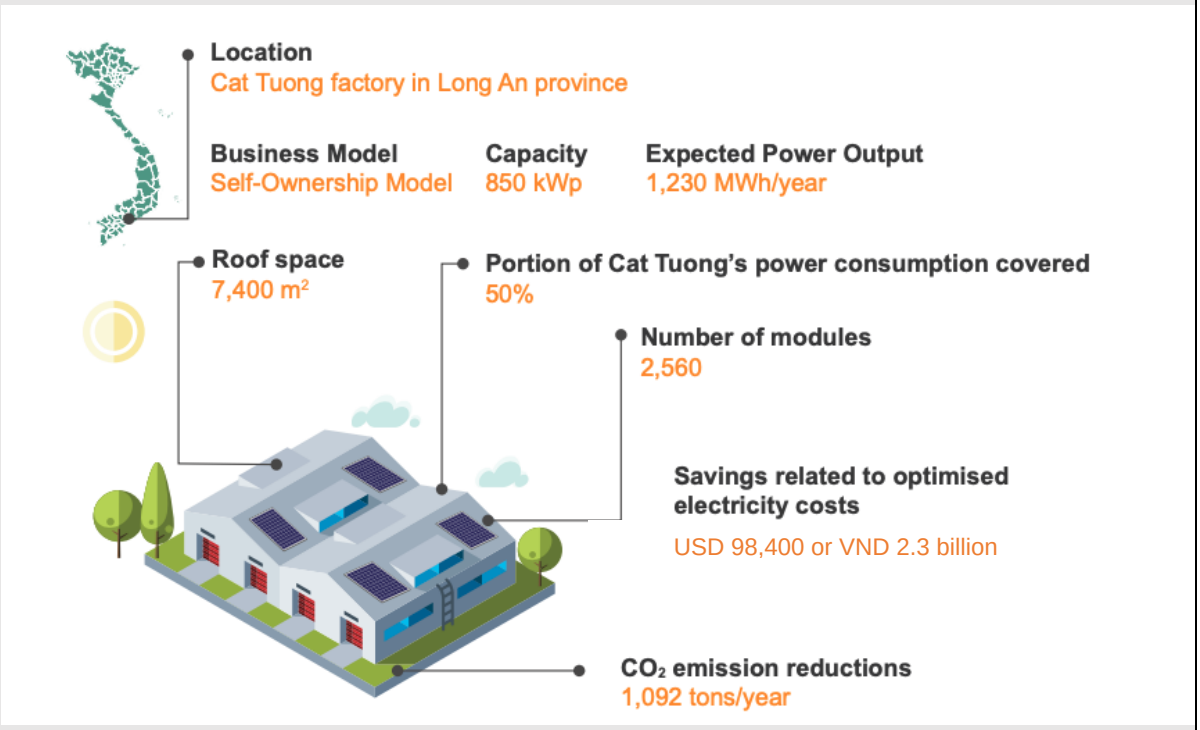
	• If not part of the tender requirements, finalise the operation and maintenance (O&M) concept. **Construction** • Continuously monitor the project against its schedule and ensure that the installation is performed with high quality components and up to high standards. • Ensure the project is on track or request penalty payments. • Final acceptance of the constructed plant and commissioning. If part of the system concept, connect to the grid.
Milestone 3	The project is constructed, commissioned and energy production has started.
Step 4: Operation	
Description	**Operation** • Continuously verify the energy produced. If a minimum production was agreed and is not delivered, request penalty payments. However, if the system PV was installed under an on-site PPA scheme, pay for the energy received. • Regularly report the status and operation conditions of the system. • Ensure the project is performing as per proposal or request penalty payments. **Maintenance** • Ensure that required maintenance is performed as stated in the schedule either by the supplier, by a third-party or by the facility owner. **Decommissioning** • At the end of the PV system lifetime its components must be decommissioned and disposed of to ensure that no environmental or social harm is done.
Milestone 4	The project is in regular operation during its entire lifetime
Step 5: End-of-life management	
Description	PV panels have an average life expectancy of 25 years and the disposal of renewable energy equipment, for instance solar panels, poses an environmental risk. Once a PV system has ended its planned lifetime you may have the option of extending its performance period, refurbishing it or repowering it to extend its lifetime, or decommissioning it to completely remove it from your rooftop. Regardless of whether you are extending the lifetime or entirely decommissioning, it is critical to **ensure that all of the replaced or discarded components are properly handled** (or better yet, recycled). PV system components are becoming a relevant source of e-waste as more systems are reaching their end of useful life at a global level. Some jurisdictions have even introduced regulations to ensure that the decommissioning and handling of the components is properly performed to avoid them becoming a source of damage to the environment or communities. While assessing proposals, make sure that a proper decommissioning and e-waste handling plan is considered to avoid unexpected costs or, in the worst case, damaging your installations.

Selecting the best provider that ensures an installation up to the highest standards will not only ensure long-term benefits, but also that all risks are mitigated. To find out more about benefits and

risks of on-site installations, please refer to **GIZ's Fabric Asia Knowledge Product Series (available under 'Further Resources tab in atingi).**

Case study/business case

Let's take a look at how a solar PV business case assessment looks in practice for Chino's solar PV project in Vietnam.



Project details

The solar project – implemented at the Cat Tuong factory inside the Lien Hung industrial zone in Long An – has a power capacity of 856.7 kWp generated by approximately 2,560 PV modules – covering 7,400 m^2 of roof space.

Project operation

The factory's solar PV system is expected to generate around 1,230 MWh of solar power annually. It is expected that this will cover (on average) around 50% of the factory's total power consumption It is expected that 100 % of the produced electricity of the solar PV system will be consumed in the factory.

Benefits

On an annual basis, the PV system is expected to save about USD 98,400 (VND 2.3 billion) from Cat Tuong factory's annual energy costs and help to reduce about 1,092 tons of CO_2 emissions.

Source: (GIZ, 2020)

Here you will find further useful resources concerning on-site solar PV:

Clean energy investment accelerator (CEIA)
The CEIA provides resources for knowledge sharing across domestic, regional, and global networks, and offers tools and lessons from CEIA target markets to inspire replication in other countries.

On this website, you will find several resources, like articles, webinars and more, dealing with solar PV in specific regions and countries (e.g. Vietnam).
Click here to see the resources.

NREL's PVWatts® Calculator
This calculator estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems throughout the world. It allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of potential PV installations.
Click here to access the website.

Solargis
The Solargis website provides several tools connected to solar PV:
Prospect: a solar prospecting tool for fast and reliable project pre-feasibility
Evaluate: for advanced energy modelling and design optimisation of solar power plants
Monitor: receive regular updates of Solargis data for performance monitoring of photovoltaic system
Forecast: solar power forecast for up to 10 days ahead
Click here to go to the Solargis website.

3.2 **Off-site Renewable Electricity**

In contrast to installing solar PV on-site, there exists the opportunity to source renewable electricity from a solar PV, wind power or any other renewable energy project, that is located off-site.

Off-site means that the power plant is not installed near a factory premises and will be larger in size (utility scale, larger than 5MW).

Companies can source renewable electricity from an off-site project either through signing a power purchase agreement (PPA) or by purchasing the respective energy attribute certificates

3.2.1 PPA

3.2.1.1 Basics

Similar to the OPEX model for on-site solar PV, off-site renewable electricity is commonly procured through a long-term contractual agreement (called power purchase agreement (PPA)) between a third party seller of electricity and either the utility or a corporate as the offtaker:

- **As a utility PPA –** this means that the generated electricity is directly fed into the local grid, sold to the local utility and via that way is sold to consumers at market prices.
- **As a corporate PPA -** this means that the electricity is sold at a fixed price to a large-scale consumer, for example a factory. You will learn more about this contracting structure in this module.

Utility power line – unsplash.com

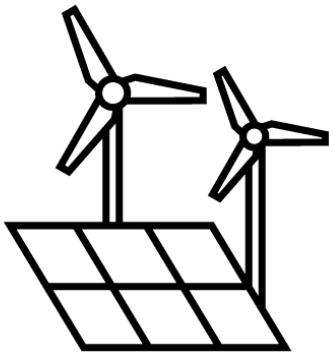
Off-site PPAs are not technology specific, they are commonly signed with solar farms, wind farms and biomass projects.

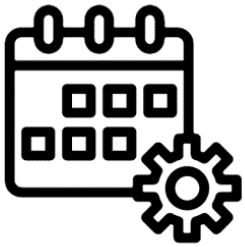
Chino Cotton Textile wants to explore further opportunities.

As Chino Cotton Textile is a corporate and wants to cover beyond the on-site generation more electricity from renewable sources, they want to further understand the opportunities of a corporate power purchase agreement.

A **corporate PPA**, is a contractual arrangement and is used when an electricity end-user (factory) signs a contract with a specific generation company to purchase electricity.

Previously, you learned that a PPA is a type of OPEX investment model for on-site generation. A PPA with utility scale RE projects is also possible in certain markets. Off-site renewable energy purchase contracts are commonly known as **off-site corporate power purchase agreements (PPAs).** Below is a more detailed explanation about off-site corporate PPAs (from left to right):





1. An off-site corporate PPA is an agreement where a business agrees to buy the power and/or the energy attribute certificates (EACs, e.g. I-RECs or TIGRs) directly from an off-site renewable energy project at an agreed price, over a fixed period, to reduce their environmental footprint and save energy costs.
2. Typically, off-site corporate PPAs are contracted with large-scale wind or solar projects.
3. A typical agreement is structured for 10–15 years, enabling the renewable energy generator to secure funding from a lender to build the project.

Having this general background, how does a corporate PPA now actually work?

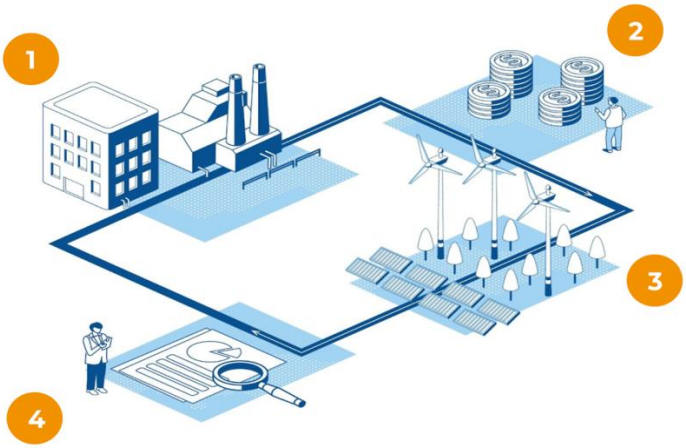


Image: A basic PPA structure

1. Companies sign long-term agreements agreeing to pay a fixed price (EUR/MWh) to a third-party seller who agrees to build, maintain and operate a renewable energy project

2. The long-term contract and fixed price from a credible corporate offtaker provides the seller with the security to receive financing for the project

3. A renewable energy project is installed by the third-party seller and delivers renewable electricity to the power grid

4. Companies receive energy attribute certificates and/or a physical supply of renewable electricity and cost savings or even earnings in return for their commitment.

Case study - Off-site corporate PPA in India

As India's largest apparel manufacturer and exporter, Shahi hopes to support the long-term sustainability of the fashion industry with a vision to power its operations with 100% renewable electricity.

It was a combination of the company's commitment and favorable regulatory policies in Karnataka which resulted in the development of a solar power project.

In March 2018, the company contracted two solar power plants of 32 MW and 52 MW capacities each in the Bellary and Bidar districts of Karnataka.

- Spread across 300 acres of land with over 250,000 photovoltaic panels (Solar PV), the plants have a capacity to generate more than 130 million kWh of electricity per year under ideal conditions.
- **Risks:** This development involved the risks related to creating a new renewable energy project.
- **Benefits:** However, the benefits included savings on conventional electricity costs in the long-term, increased energy independence, and less exposure to fluctuating electricity costs. In 2019-2020, the solar plants catered to 65% of the company's electricity requirement.
- **Emission reduction:** Around 125,196 MWh electricity was generated through the solar plants avoiding 103,000 MT (megaton) of emissions. This emission reduction is equivalent to saving 70,000 MT of coal reserves used in a thermal power plant annually to generate the same amount of electricity.

Source: Shahi Exports (2021)

3.2.1.2 Key consideration - Availability

Whether off-site PPAs are an option depends on your market and are more common in deregulated power markets (for example in the United States, Europe and Australia). The availability of off-site PPAs is currently limited to more mature RE markets.

In **Asia**, off-site corporate PPAs are only available in India, Singapore, Japan, and Taiwan with near term (next 2–3 years) opportunities in Vietnam, Philippines and Malaysia.

Country	**Off-site Corporate PPAs** Long-term electricity contract with an off-site, typically large-scale RE generator
Bangladesh	x
Cambodia	x
Myanmar	x
Pakistan	x
China	x
India	✓
Vietnam	Pilot programme being planned
Italy	✓
Turkey	x
Romania	✓
Poland	✓

Spain	✓
Portugal	✓
Bulgaria	✓
Peru	x

[Exercise 4]

What are the differences between on-site and off-site solar PV?

On-site

- The solar system is on or near your factory
- Typically the factory will directly consume the generated power
- Typically limited by the available area for the installation and the RE potential of the location
- Typically only covers a small portion of the site's total consumption

Off-site

- The RE project is not located on the premises of your factory
- The project is large scale and the generated electricity feeds into the grid
- Can generate significant amounts of electricity and possibly cover the entire needs of a factory

3.2.2 Energy attribute certificates (EACs)

(Unbundled) Energy Attribute Certificates are an emission reduction instrument that do not require a physical transfer of renewable electricity. They are particularly interesting for textile and garment companies, which have already exploited their on-site solar PV potentials and have no opportunity to source off-site renewable electricity.

Chino Cotton Textile wants to address remaining electricity emissions

As PPAs are not available yet and the own on-site installation only cover a small portion of Chino Cotton Textile's electricity consumption, the management wants to understand how EACs can be used to further increase the share of renewable electricity.

3.2.2.1 Basics

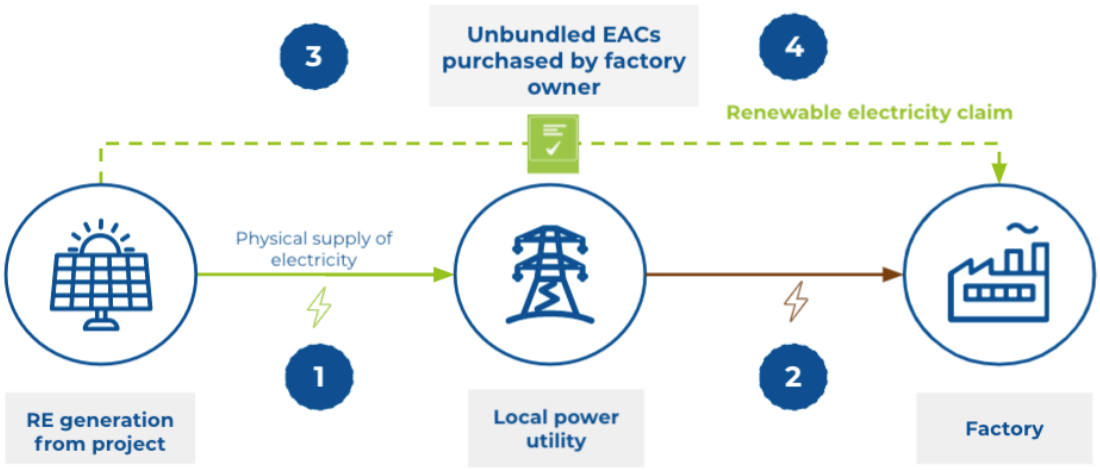
Energy attributes certificates (EACs) are known by different names in different schemes and geographic areas. In some countries a national tracking system has been established. For example, Chinese Green Energy Certificates (GECs), Japanese J-Credits, or Taiwanese T-RECs.

For countries without a national system, internationally recognised standards are available. For example, the International REC Standard **(I-RECs)** can be found in several Latin American, African and Asian countries, as can Tradable Instrument for Global Renewables **(TIGRs).**

In European countries, Guarantees of Origin (**GoOs**) are common.

How does it work?

1. A renewable energy project sells generated renewable electricity to the local grid.
2. You source electricity from the local grid, however the renewable electricity is mixed with the power generated from other power plants, including fossil fuels. In other words, the physical electricity we receive through the power grid arrives without information on how or where it was generated.
3. You purchase an amount of EACs equal to their electricity consumption (remember: 1 EAC = 1MWh of renewable electricity).
4. By purchasing EACs, you can claim the green attribute of renewable power generation.



EACs trade separately from the underlying physical electricity, allowing buyers to purchase and meet targets in a credible, internationally recognised, and reportable way. **EACs are a flexible and easy way:**

- to achieve renewable energy targets
- to reduce Scope 2 emissions
- to meet customer expectations around sustainability

[Exercise 1]

Match the measures to the correct Scope!

Scope 1

- On-site biomass boiler
- Solar thermal for heat generation

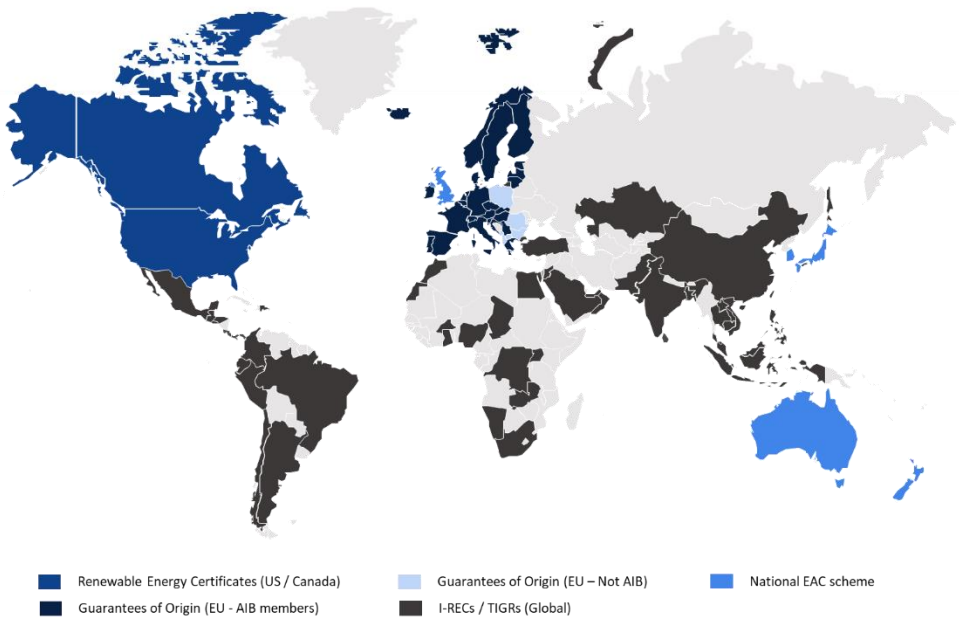
Scope 2

- On-site solar PV for power generation
- Power purchase agreement (PPA) for off-site RE power
- Energy attribute certificates (EACs)

3.2.2.2 Key consideration - Availability

As mentioned in the beginning, based on the geographic location, there are different EAC schemes in place with each one having separate regulations. Some countries also haven't committed yet to any EAC scheme.

Below you find a map with the latest information on where which EAC schemes are available around the globe (from September 2022).



For the garment and textile industry especially, the following countries are the most relevant:

Country	**Unbundled EACs** Certificates purchased from the market
Bangladesh	✓ I-RECs and TIGRs (Tradable instruments for grid renewables) Note: I-RECs and TIGRs have only recently been introduced in Bangladesh)
Cambodia	✓ I-RECs and TIGRs
Myanmar	x
Pakistan	✓ I-RECs and TIGRs
China	✓ I-RECs and national scheme (GEC)
India	✓ I-RECs and TIGRs
Vietnam	✓ I-RECs and TIGRs
Italy	✓Guarantee of Origins (GoO)
Turkey	✓IRECs
Romania	✓GoO
Poland	✓GoO
Spain	✓GoO

Portugal	✓GoO
Bulgaria	✓GoO
Peru	✓IRECs

[Exercise 2]

The fictional company, North Sewing Ltd. is, as you know, based in Vietnam. North Sewing's management wants to become sustainability leaders and reduce Scope 2 emissions by 100% by 2025. within the next 18 months.

Which solutions could North Sewing explore to reduce Scope 2 emissions?

- On-site solar PV for power generation **(correct)**
- Unbundled EAC **(correct)**
- Off-site RE corporate PPAs **(correct)**
- Diesel-powered generator

Your recommendations are wise.
By advising North Sewing to source renewables, you have helped them to reduce emissions and become a more sustainable company. Not only will North Sewing be able to report fewer CO_2 emissions, but with renewables they may save costs on power procurement and be better prepared for future fluctuating power prices. While on-site generation will not, in most cases, be able to cover 100% of your power needs, you are correct in suggesting that other emission reduction solutions such as EACs can be explored.

4. Lesson: Renewable Heat - Biomass

Until this point we have learnt quite a lot on the different ways of procuring renewable electricity. But now you may rightly ask: **And what about all our applications running with thermal energy like coal? Are there any renewable heating alternatives to reduce my carbon emissions?**

As an answer to these questions, we will focus in the following lesson on **biomass as the most relevant renewable heating technology to the textile and garment industry**. Biomass has significant potential to mitigate GHGs if resources are sustainably developed/sourced and efficient technologies are applied.

4.1 Basics

Biomass can have various energy-related applications in the textile and garment industry.

As we have learnt, the textile and garment industry is a major consumer of not only electrical energy – mainly for the operation of industrial equipment – but also of thermal energy for the production of heat (steam) essential to different productive processes.

- Biomass can be used for **power generation**.
- Biomass can be used as a substitute fuel for **heat production**. For example, for steam production or for boilers.
- Biomass can also fuel a cogeneration facility also known as **combined heat and power (CHP) to produce both electricity and heat**.

In fact, generally, GHG emissions are most reduced when waste biomass is converted to combined heat and power (CHP) in modern energy plants near the location where the waste is generated. This is also called cogeneration.

[Exercise 6]

What can biomass by-products or wastes in the textile industry be used for?

- Heating applications **(correct)**
- Electric power generation **(correct)**
- Combined heat and power generation **(correct)**

Biomass in the textile industry can be used for heating applications and/or electric power generation.
To use biomass for power or heat generation, it needs to be converted into energy (see methods

Bioenergy technologies convert renewable biomass fuels into heat and electricity using various processes. To fully understand the different types of biomass and how they are produced, let's have a look at the underlying supply chain!

The biomass supply chain:

1) Sourcing biomass (sources)

The first step in the biomass supply chains is the sustainable harvesting and collection of feedstock, for example: woodfuels, agricultural by-products, or animal by-products. Sustainably sourced biomass is derived from the by-product of other industries (wastes and residues) or is sourced from a certified source.

2) Creating biofuel

The collected biomass is converted into, for example: solid fuel wood, charcoal, wood pellets, briquettes, bioethanol, biodiesel.

3) Generating bioenergy by converting biomass to energy (heat and electricity)

Biopower technologies convert renewable biomass fuels into heat and electricity. In general, there are three ways to harvest the energy stored in biomass to produce biopower: burning, bacterial decay, and conversion to a gas or liquid fuel.

Several processes to release the energy stored in the biomass

Direct combustion	Anaerobic digestion	Gasification	Pyrolysis (conversion)
The most common is direct combustion of biomass material, such as agricultural waste or woody materials.	Anaerobic digestion, also known as bacterial decomposition, produces a renewable natural gas when organic matter is decomposed by bacteria in the absence of oxygen.	Gasification produces a synthesis gas with usable energy content by heating the biomass with less oxygen than needed for complete combustion.	Pyrolysis is a type of gasification that yields bio-oil by rapidly heating the biomass in the absence of oxygen. There are also processes that convert biomass to more efficient sources of energy, for example **torrefaction (*).** (*) Torrefaction is a thermal process to convert biomass into a coal-like material, which has better fuel characteristics than the original biomass.

The term biomass encompasses a large variety of materials, including wood from various sources, agricultural residues, and animal and human waste.

How various sources of biomass are typically processed	
Biomass source	**Process**
Corn stover, rice husk and straw	Corn stover, rice husk and wheat straw residues are baled for combustion or converted into a gas using an anaerobic digester. Rice husk and straw are the most produced biomass source in Southeast Asia.
Woody biomass	Typically, woody biomass such as wood chips, pellets and sawdust are combusted or gasified to generate electricity. Its availability within South East Asia depends on the specific region and sustainable sourcing needs to be verified.
Wet waste	Very wet wastes, like animal and human waste, are converted into a medium-energy content gas in an anaerobic digester.
Other types	In addition, most other types can be converted into bio-oil through pyrolysis, which can then be used in boilers and furnaces. Cassava stem/stalk, coconut shell, coffee husk, peanut husk and shell are some examples of other common biomass sources.

A range of biomass pre-treatments and upgrading technologies have been developed in order to improve biomass characteristics and to make handling, transportation and conversion processes more efficient and cost effective.

This results in biomass being available in different forms, depending on the treatment, e.g.

- as pellets (through pelletisation)
- as a coal-like substance (through torrefaction)
- as gas (through gasification)
- as oil (through pyrolysis)

Biomass pellets
Source: GIZ photopool

4.2 Key considerations

What are the main topics to consider when transitioning to biomass?:
When considering biomass, the key topics to keep in mind include:

- Logistics and infrastructure – have a high impact on the pricing, locally sourced would be easier and cheaper
- Storage – Biomass will need more space to produce the same amount of heat
- Price – The price of biomass might fluctuate depending on the season and quality
- Seasonality – Especially agricultural byproducts are highly abundant in harvesting times, and not abundant the rest of the year. A combination of fuels could be considered.

When should you consider integrated biomass energy into your operations?

Let's ask the experts! These questions will help you decide if it's time to explore biomass.

- Do you have thermal loads throughout the year (such as steam, hot water, chilled water, hot oil or hot air)?
- Do you expect to replace, upgrade or retrofit central plant equipment (such as generators, boilers, and chillers) within the next three to five years?
- Do you anticipate a facility expansion or new construction project within the next three to five years?
- Have you already implemented energy efficiency measures and still have high energy costs?

What about the emissions?

As far as air emissions are concerned, biomass CHP (Combined Heat and Power) plants have to comply with strict emissions limits applied by the province/state, as well as the national/federal government.

Compared to gaseous fuels (e.g. natural gas), solid fuels usually need stronger air pollution control. To achieve this, different kinds of gas control measures can be applied on biomass boilers, such as dust cyclones and scrubbers.

What are the main sustainability topics to consider when transitioning to biomass?

Sustainable biomass sourcing is a key component of a successful project.

It is important to use trusted biomass, primarily as a by-product of other industries or from **certified sources**. **Certification provides traceability and assurance** that biomass is sourced legally and sustainably.

Sustainability factors to be aware of when sourcing biomass are:

- Legality of harvesting operations
- Regeneration of harvested areas
- Ensuring that harvesting maintains or improves the long-term production capacity,
- Evidence that carbon stocks and sinks do not exceed removals,
- Impacts on biodiversity,
- Exclusion of harvesting from designated protection areas, primary forest and land with high carbon stocks (e.g. wetlands, peatland).

For example, wood chips may be classified as a sustainable source if they are by-products of other industries, or certified managed forest. Biomass sourced from deforestation is not sustainable and therefore fails to deliver environmental benefits.

Other types of organic biomass should come from certified and trustable sources, for example as a side product of the food/agricultural industry.

Case study – Biomass boiler: A textile company in Vietnam is currently using biomass boilers.

Source: Crystal International Group Limited

- These boiler capacities are from eight to 12 metric tons (mton) of steam per hour. They are fuelled by various kinds of biomass pellets (usually made of agricultural waste).
- Based on monthly data, the fuel-steam ratios can achieve 0.2 or even lower (i.e. 1 mton of biomass for 5 mton of steam or more).
- If the factory was using diesel boilers, generating 1 mton of steam at least requires 60 litres of diesel.

Each mton of steam is equivalent to ~160 kgCO_2e of Scope 1 emissions.

And what about the rules for interconnection for grid-connected on-site plants that generate electricity?

For on-site electricity technology, the rules for interconnection/net metering may be different if the system is a combined heat and power system instead of only for electricity production and depend on each country.

The ability to take advantage of a net metering/feed-in tariff may also be crucial to system economics.

4.3 Business models

At this point, you are probably thinking about costs. So let's explore the biomass boiler investment models. As with solar, you can either operate the system yourself, or contract a company to install and operate the system.

1. **Self-operating**

Under the self-operating model, the factory invests in biomass technology and is responsible for day-to-day operation and maintenance of the system. For this model it is important to ensure that staff are well trained to ensure efficient operation of the system in the long term.

2. **ESCO (energy service company model)**

The **ESCO model** for biomass boilers can be compared to the OPEX model for on-site solar PV. Under this model, a company will install and/or operate biomass-based boilers/heaters providing the factory with a supply of fuel and take responsibility for operation and maintenance (O&M).

While the ESCO manages the installation and the day-to-day operation of the boiler system, it is advisable that at least one of the factory's staff receive basic training on system operation.

Chino Cotton plans to replace production equipment in the near future and is looking to save on operation costs as well as reduce emissions.

This is how the company proceeds:

1. It conducts a feasibility study for replacing the existing boiler with a biomass boiler.
2. It evaluates other environmental impacts, in particular air quality of boiler emissions and impact of solid waste, which need to be carefully monitored and controlled.
3. It evaluates if reliable fuel suppliers and sufficient on-site storage space are available.

[Exercise 7]

Biomass total cost savings depends on which of the following factors?

- Which type of biomass you use and where it is sourced from **(correct)**
- Your alternative fuel-source costs **(correct)**
- How efficient your biomass facility is **(correct)**
- Your total energy consumption **(correct)**
- Cost of installation **(correct)**

How much you can save depends on several factors across the biomass value chain!

The type of system best suited to a particular application depends on many factors.

What do you think are some of these factors?

Some decision-making factors for biomass are:

- availability of the feedstock and pre-treatment requirement
- Sustainability of the feedstock
- Moisture content of biomass (i.e. lower fuel efficiency for high moisture content)
- competing fuel cost (e.g. fuel oil and natural gas)
- peak and annual electrical loads and costs
- steam demand
- building size and type, space availability
- operation and maintenance staff availability
- local policy and regulations (including emission regulations)

What are some recommendations which are critical to the success of any biomass energy project?

1. Fully involve decision makers during the planning stages and as progress is made.

2. Work closely with an engineering consultant company to check the technical feasibility of the boiler system and select the most suitable business model.

3. Secure long-term biomass supply contracts and ensure biomass resources are sustainably produced.

Finally, let's take a look at the costs of a biomass boiler using a case study below!

A factory in Vietnam used a diesel boiler for steam generation. To determine the feasibility of switching boiler fuel, the facility team compared different types of boilers for identifying the corresponding costs and benefits. Here are the financial figures.

	The existing diesel boiler	The proposed biomass boiler
Initial investment cost (USD)	N/A	235,000
Average monthly fuel demand	100,000 L of diesel	330 tonnes of biomass
Average monthly fuel cost (USD)	57,000	28,000
Average monthly operational costs (USD)	2,200	6,000
Average annual cost (USD)	710,400	408,000
Annual saving (USD)	N/A	302,400

Source: A global textile supplier (2018)

While the operation and maintenance costs of the biomass boilers are higher than the average costs associated with the diesel boiler - the cost savings from biomass fuel offset this.

The payback period of replacing the diesel boiler was estimated to be within one year

5. Quiz

We are almost at the end of Module 5.2: Renewable energy and biomass

Did you do the self-evaluation at the start of the module? If so: were your expectations met?

Compare your personal take-aways with the notes you might have made when starting the module.

Before we proceed with the practical assignment, check your knowledge with a short quiz.

[Quiz 1]

What are examples of biomass residues that can be used to produce energy?

- Sugarcane **(correct)**
- Corn stover **(correct)**
- Straw **(correct)**
- Wheat straw **(correct)**
- Wheat

Ideally, energy production from biomass should not use raw agricultural biomass, to avoid competition with food production. Therefore, the use of agricultural residues should be prioritised.

[Quiz 2]

What differentiates the OPEX model from the CAPEX model for on-site RE system financing?

- In the OPEX model, the factory would typically be responsible for its operational and maintenance activities and costs.
- The factory does not own the solar PV system under the OPEX model **(correct)**
- Costs for operations and maintenance are free
- Cost saving potential depends on the agreed discount rate against the retail rate **(correct)**

[Quiz 3]

What are the common measures to reduce Scopes 1 and 2 emissions?

- Scope 1 emissions: on-site biomass boiler, on-site CHP **(correct)**
- Scope 2 emissions: diesel generator
- Scope 2 emissions: EACs, on-site solar PV **(correct)**
- Scope 1 emissions: green tariffs
-

[Quiz 4]

What are the important considerations when installing a solar PV system?

- Rooftop should be structurally sound and not in need of repairs or replacement **(correct)**

- Rooftop space should be shaded (e.g., by trees, walls, vents) to ensure that the system is not easily damaged
- Make sure there is available space on your roof: typically 5-7 sqm/kWp installed is necessary. **(correct)**
- Make sure there is high exposure to solar irradiation where the factory is located. **(correct)**
- Understanding and checking the quality of the offered solar panels is less important, as the solar panel vendor will often give us the best panels.

[Quiz 5]

Which of the following statements are correct?

- Solar flat plate collectors are the best type of collectors to produce heat for steam
- The hot water produced from a solar thermal system can be used directly in industrial processes **(correct)**
- Solar thermal systems work in the same way as solar PV systems

[Quiz 6]

What are the factors influencing the amount of electricity that your solar PV system can generate?

- Location (solar irradiation) (**correct)**
- Space availability **(correct)**
- The material and efficiency of the solar panels used **(correct)**
- Proper operation and maintenance **(correct)**

6. Your assignment for this week

1. Assess if your factory has a suitable location for a solar PV project.

- Does your factory own the building or have a long-term lease (10+ years)?
- Do you have space available on your roof for solar panels and/or sufficient land for a ground-mounted system?
- Is the roof structurally sound and will it be in place for the duration of the economic life of the solar PV system (typically, 20–25 years?)
- Are there no trees, walls, buildings, or other structures that shade the area where the solar panels would be located?

If you answer YES to all these questions, your factory may be is well positioned to consider solar. If you answered NO to some of these questions, don't worry! It is still worth discussing your options with a trusted adviser.

2. Assess your business priorities to identify the ideal financing approach for your system.

- Does your company allow the use of operational budgets to lease equipment? Or does your company's budget allow for equipment to be purchased with capital budgets?
- If your company is interested in a solar lease, would it be able to sign at least a 10-year contract?
- Would your solar PV system qualify for incentives, such as net metering and tax breaks?

3. Now, let's evaluate the potential annual output of a solar PV system in your factory by checking the following parameters:

- available rooftop/near site area (m^2)
- solar irradiation (global tilted irradiation at optimum angle in kWh/m^2/year) by clicking your location in this map
- calculate the expected solar system output (kWh/year) with the following formula: available area x solar irradiation

4. Let's list the three to four potential solar system installation providers and their contact details within your city/region/area.
5. Reach out to providers and start your journey to emission reductions and cost savings with solar PV

7. Frequently Asked Questions

Solar PV

How do you calculate the sizing of the system from the available space?

Answer: A simple estimation using the solar PV calculator could be obtained here: https://globalsolaratlas.info/map. In this database, you can input the factory's location (ideally the city/municipality name) to obtain the following information:

- Irradiation: the estimated annual PV power output per m^2
- Specific PV power output: the estimated annual PV power output per kilowatt (kW) installed system size
- Simple calculator to estimate the power generation based on specific system size or available area

What are the main reasons behind the variation of financial returns among different on-site systems installed in different factories?

Answer: On-site solar PV system generation depends on various aspects, both from the technical and environmental aspects including, but not limited to, the listed points below. Any difference in these parameters would affect the power output from the solar PV system, hence cost-saving potential and financial returns of the PV system.

- the installed PV panel tilt angle
- the type of PV panel used (material, efficiency)
- arrangement and efficiency of the balance of system
- potential shading and other obstruction
- implementation of battery storage
- the solar energy potential (irradiation) at different locations
- the variation in solar energy intensity throughout the day
- the local weather and seasonal variations

What is the use of a detail load profile?

Answer: The factory's load profile information is useful to design the most suitable solar PV system configurations with the factory needs – in terms of the size, system location, connections, the significance of battery storage, etc.

You should work with energy managers to analyse utility bills – ideally looking at your usage over the past two years – to understand the factory's daily, seasonal, and annual electricity consumption patterns.

Without taking into account the factory's load profile, there is a risk of inefficiencies in the on-site PV system design, such as inadequate system capacity which could significantly reduce the cost-saving potential and financial returns of the PV system.

Shall I wait for solar technology to improve or prices to go down?

Answer: Today, solar PV systems are fully commercial and becoming a routine business solution for industrial and commercial customers in most markets. The technology is already cost competitive, in most cases, when compared with fossil fuels, and the on-site systems already provide cost-savings potential.

What will happen on a rainy day or during the rainy season?

Answer: Your solar system will generate electricity when the sun is shining. When the system is not generating electricity you can continue to draw power from your local power supplier/utility as normal to power your operations.

Will I still be able to use solar electricity during a blackout?

Answer: During a blackout (power outage) your solar system will continue generating electricity as normal, however if you do not have an energy storage system, you will typically not be able to use that energy to run your factory during a power outage because your solar system will automatically shut off for safety reasons.

If your factory is located in an area prone to power outages, discuss your technical options with your trusted solar PV adviser to ensure a continuous power supply.

Will I need a battery for my solar system?

Answer: A battery, or energy storage, is typically not needed for on-site solar PV unless you are not connected to the local power utility.

How can diesel gensets and gas turbines synchronise with solar PV?

Answer: If you are using a diesel genset or gas turbine to produce power (i.e. you are off-grid) the way it works will not change once the solar PV system is installed – you will only use it less!

The electricity produced by the solar PV system will be used with priority to cover some (or all) of your consumption. It may happen, nevertheless, that the solar PV system is not producing enough (or any) electricity to cover your demand (e.g. during the night or on cloudy days) and you still require electricity to keep working. If that happens, the backup will have to start to operate and produce the required electricity.

If you are connected to the grid and use your diesel genset or gas turbine as a backup for grid failures, though, the solar PV system alone will not be able to reduce its usage, since all PV systems connected to the grid are required to be shut down in case of grid failures. This means that even if the sun is shining, your PV system will not produce energy during a grid blackout.

If you want to reduce the need for diesel gensets or gas turbines, it is then recommended to install a battery system that will provide electricity to your factory during blackouts.

Does the solar system require regular operation and maintenance (O&M)?

Answer: Yes! To maximise the power generation potential and life span of your system, regular and appropriate maintenance is required. The costs of this need to be considered when assessing the business case for your system. This includes for example proper administration, operation, inspection, cleaning, preventative and corrective maintenance, and proper disposal at the system's end of lifespan.

Under the CAPEX model, you are responsible for O&M throughout the life of your system and should assign trained personnel to be responsible for this. You can also contract a local RESCO (typically for an annual fee) to be responsible. Under the OPEX model, the contract RESCO will be responsible for O&M.

What are the major reasons for the failure of solar projects?

Answer:

- Inexperienced developer installing your system
- Lack of proper technical assessment before installing a system
- Low-quality materials, components, and mounting structure installations, which result in sub-optimal PV system performance or other infrastructure failures
- Electric surges coming from the utility grid or natural events (such as lightning)
- Lack of proper maintenance throughout the solar PV system's operation

In summary, proper installation by a qualified developer, using quality parts, is a key success factor, limiting failure of the project.

Biomass

What are the main energy applications for biomass in the textile industry?

Answer: Biomass has various applications in the textile and garment industry, including heat and electricity generation. Biomass offers a means to reduce energy related emissions for the textile industry, traditionally an industry with high energy expenditures.

- Biomass for heat: biomass may be used to produce steam for applications with higher thermal requirements, such as dry cleaning and dyeing.

- Biomass for electricity generation: biomass may be used as the feedstock to power machinery, lighting, office equipment and other operations.

Generally, GHG emissions are most reduced when waste biomass is converted to heat or combined heat and power (CHP) in modern energy plants near the location where the waste is generated.

What are the sustainability concerns of biomass?

Answer: Biomass has the potential to deliver substantial emission reductions and sustainability benefits. However, if biomass is not sourced sustainably its consumption may be linked to deforestation, negative impact on biodiversity and increased emissions. When sourcing biomass one should, therefore, place close attention to the: legality of harvesting operations, regeneration of harvested areas, ensuring that harvesting maintains or improves the long-term production

capacity, evidence that carbon stocks and sinks do not exceed removals, impacts on biodiversity, exclusion of harvesting from designated protection areas, exclusion of primary forest, and exclusion of land with high carbon stocks (e.g. wetlands, peatland).

How can you ensure your biomass is sustainably sourced?

Answer: Biomass has significant potential to mitigate GHGs if resources are sustainably developed/sourced and efficient technologies are applied. Sustainably sourced biomass is derived from the by-product of other industries (wastes and residues) or is sourced from a certified source. Certification provides traceability and assurance that biomass is sourced legally and sustainably.

8. Resources

General information on renewable energy

UN, What is renewable energy? | United Nations (regularly updated)

Renewable energy solutions for textile factories

Some key material providing information about drivers for corporate renewable energy procurement:

RE100, Growing renewable power: companies seizing leadership opportunities, (2020). [PDF, 32 pages]

RE-Source, On-site renewable electricity and storage for corporates: business models & policy framework, (2020). [PDF, 58 pages]

International Energy Agency, Renewable Energy Market Update - Outlook for 2022 and 2023, (2021). [PDF, 29 pages]

GIZ Vietnam and develoPPP.de. Investing in rooftop solar systems in Vietnam: Technical and administrative guidelines for commercial and industrial projects, (2020). [PDF, 71 pages]

GIZ Energy Support Programme, Why Bioenergy - Scoring climate goals with bioenergy, (2016).

GIZ and Ministry of Industry and Trade Vietnam, Biomass energy project development guidelines, (2017). [PDF, 152 pages]

National Renewable Energy Laboratory, PV modules end-of-life management - Setting the stage, (2019). [PDF, 15 slides]

National Renewable Energy Laboratory, Best practices at the end of photovoltaic system performance period, (2021). [PDF, 32 pages]

Here you will find some useful further resources regarding on-site solar PV:

Clean energy investment accelerator (CEIA)

The CEIA provides resources for knowledge sharing across domestic, regional, and global networks, and offers tools and lessons from CEIA target markets to inspire replication in other countries.

On this website, you will find several resources, like articles, webinars and more, dealing with solar PV in specific regions and countries (e.g. Vietnam).

Click here to see the resources.

NREL's PVWatts® Calculator

This calculator estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems throughout the world. It allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of potential PV installations.

Click here to access the website.

Solargis

The Solargis website provides several tools connected to Solar PV:

Prospect: a solar prospecting tool for fast and reliable project pre-feasibility

Evaluate: for advanced energy modelling and design optimisation of solar power plants

Monitor: receive regular updates of Solargis data for performance monitoring of photovoltaic system

Forecast: solar power forecast for up to 10 days ahead

Click here to go to the Solargis website.